PART 5

Screening-Level Ecological Risk Assessment Updates

Screening-Level Ecological Risk Assessment COB Energy Facility, Bonanza, Oregon

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1. Introduction

A screening-level ecological risk assessment (ERA) following U.S. Environmental Protection Agency (EPA) and Oregon Department of Environmental Quality (ODEQ) guidance was conducted to determine the potential risk to plants, soil invertebrates, and wildlife from air emissions at the COB Energy Facility, and, separately, the potential risk of using process wastewater to irrigate 31 acres of pasture and to improve grazing forage yield in areas currently without irrigation. Because there is an active bald eagle nesting area near McFall Reservoir, located approximately 6 miles south of the proposed facility location, and because bald eagles also use other areas in the vicinity of the proposed Facility location (e.g., Smith Reservoir), the U.S. Fish and Wildlife Service (USFWS) has expressed concern about the potential impacts of the air emissions of the Energy Facility on bald eagles and their habitat. Two endangered fish species (shortnose sucker and Lost River sucker) that historically have been found in the Lost River, located 2 miles north of the Energy Facility, and one plant species (Applegate's milk-vetch) are of concern as well.

The screening-level ERA was conducted as part of the biological assessment (BA) to address potential risks under two scenarios. Under the first scenario, the potential risk from air emissions (and subsequent deposition to surface water) to aquatic organisms and to the bald eagle (with exposure via food web transfer) was evaluated. Upland areas surrounding the Energy Facility site also were evaluated for possible risks to terrestrial plants, soil invertebrates, and terrestrial birds and mammals resulting from terrestrial deposition of air emissions. Under the second scenario, possible risks to terrestrial plants, soil invertebrates, and terrestrial birds and mammals ~~and~~ from reuse of the process wastewater for irrigation were assessed.

The procedures used in conducting the ERA are consistent with those described in the following ODEQ and EPA guidance documents:

- Guidance for Ecological Risk Assessment: Level II Screening Level Values (ODEQ, 2001)
- *Framework for Ecological Risk Assessment* (EPA, 1992a)
- *Final Guidelines for Ecological Risk Assessment* (EPA, 1998a)

Ecological risks were evaluated on the basis of conservative assumptions, maximum estimated media concentrations, and screening toxicity values. As is appropriate for a screening-level assessment, risk is not discussed in terms of the potential to cause risk, but in terms of passing or failure to pass the screening evaluation. This screening assessment was based on conservative assumptions such that constituents that passed the screen can be considered to pose no significant risk to ecological receptors. Failure to pass the screen, however, cannot be concluded to represent the presence of risk. Rather these results indicate that available data are insufficient to support a conclusion that ecological risks are absent. Constituents that failed the screen were reevaluated using more realistic assumptions.

This ERA is presented in four sections: problem formulation, exposure assessment, effects assessment, and risk characterization.

2. Problem Formulation

The problem formulation is the first and most critical component of any risk assessment. It involves identifying the problem and chemicals to be addressed, describing the affected site, selecting assessment and measurement endpoints, and developing a site conceptual model and data quality objectives. The problem formulation serves to provide direction and focus to the assessment process.

2.1 Site Description

This section summarizes the location and environmental setting of the Energy Facility (see Sections 2 and 4 of the BA for a more detailed discussion). Briefly, the Energy Facility site is located 3 miles south of Bonanza, Oregon, and 34 miles east of Klamath Falls, Oregon. The Lost River is located approximately 2 miles north of the Energy Facility site and Bryant Mountain is located approximately 1 mile south of the Energy Facility site. Various habitat types within the expected impact area of the Energy Facility include western juniper woodland, Ponderosa pine forest, sagebrush-steppe, ruderal areas, agricultural lands, and several riparian areas associated with the water resources in the area (e.g., Klamath River and tributaries).

2.2 Contaminants of Potential Ecological Concern

Contaminants of potential ecological concern (COPECs) are those chemicals that are present at the site in concentrations that may exceed toxicity thresholds for ecological receptors. This ERA evaluates estimated media concentrations modeled from the air emissions predicted from the natural gas combustion at the Energy Facility and estimated soil concentrations from land application of process wastewater. The significant impact area for air emissions is depicted in Figure 1. This area represents the area where annual average ambient particulate matter under 10 microns (PM_{10}) concentrations of 0.2 $\mu g/m^3$ or greater are predicted. Concentrations at or above this value are defined as significant air quality impacts in the Oregon air quality regulations (OAR 340-200-0020). Oregon's PM_{10} significance level is more stringent than the federal PM_{10} significance level of 1 $\mu g/m^3$ and is therefore considered to be conservative. The percent of aerial deposition at the Energy Facility and that in the primary deposition area are not measurable within the modeling framework. However, incremental soil concentrations (i.e., those above background) from aerial deposition outside the significant impact area are predicted to be very low and are unlikely to contribute to estimated risk. Because the ~~primary deposition~~significant impact area for air emissions is outside the Energy Facility site (see Figure 1) and deposition outside this impact area is predicted to be very low, ~~the~~ significant deposition from air emissions is not expected to overlap with the process wastewater application area. These two inputs, therefore, were considered separately and were not considered to be additive in soil. Methods used for estimating soil and water concentrations under the two scenarios (i.e., air emissions and process wastewater application) are described below.

2.2.1 Air Emissions

Predicted hazardous air pollutants (HAPs) and their estimated annual emissions are presented in Table 1 along with the estimated annual emissions of ~~particulate matter under 10 microns (~~PM_{10}~~)~~. The methods used to estimate HAPs for the COB Energy Facility are described in detail in Section 2 of the air permit application. Briefly, annual emissions of HAPs were estimated using established EPA emission factors for HAPs (EPA AP-42), supplemented with a recent memorandum from EPA's Office of Air Quality Planning and Standards (OAQPS) regarding formaldehyde emissions from natural-gas-fired combustion turbines employing lean premix combustion. HAP emissions from combustion turbines and duct burners at the proposed facility were conservatively estimated based on 55 percent control efficiency for organic HAPs. Additionally, conservative estimates of heat input rates and annual hours of operation were assumed for each HAP emission source. These conservative assumptions resulted in "worst-case predictions" for HAP emissions.

~~Additionally,~~In addition to the estimated annual emissions, the distribution of ground-level air concentrations of PM_{10} was modeled for a radius of 6 miles around the Energy Facility. The area predicted to have PM_{10} concentrations of 0.2 µg/m^3 or greater (Oregon air quality regulation) ~~the highest~~ ~~PM_{10}~~ ~~concentrations~~ is depicted in Figure 1. A detailed description of the model used to estimate PM_{10} concentrations is provided in Section 5 of the air permit application. Salient points of the model are described below:

- A class II air quality analysis was conducted using the EPA-approved ISCST3 (Version 020235) model. This model was run using regulatory defaults, direction-specific building downwash, actual receptor elevations, and complex and intermediate terrain algorithms (as appropriate).

- Meteorological data collected at the project site since late October 2001 were processed using the EPA Meteorological Processor for Regulatory Models (MPRM) program. These data indicated that prevailing winds are from the northwest (i.e., they are blowing in a southeast direction). Therefore, the significant impact area for aerial deposition is predicted to occur to the southeast of the proposed facility location.

- The analysis used a nested receptor grid centered on the proposed Facility site with 50-meter spacing out to 1 km, 100-meter spacing out to 5 km, and 500-meter spacing out to 10 km. A fenceline receptor grid with a 50-meter spacing was also used.

- A 6-mile (or 10-km) radius was selected as a realistic initial grid size for the air emissions model. Within this grid, the concentration of PM_{10} was determined at each receptor point over the time period (annual in this case). Each point along the edge of the grid was checked to ensure that PM_{10} concentrations were below those predicted in the significant impact area. If PM_{10} concentrations were greater than 0.2 µg/m^3, the grid would have been expanded to encompass a larger area. However, in the case of the COB Energy Facility model, these concentrations were less than those in the impact area and the grid size was kept at 6 miles.

Although organic constituents are estimated in the air emissions (see Table 1), EPA (1999) reports that all the organic HAPs are in the vapor phase (vapor phase fraction 100 percent; EPA, 1999).~~, and t~~Thus, organic HAPs are not expected to have significant deposition to soil or water in the Energy Facility area. Most of the polycyclic aromatic hydrocarbons (PAHs) also are in the vapor fraction (greater than 75 percent; EPA, 1999), and will not have significant deposition in the modeling domain. As a result, the organic HAPs are assumed to vaporize and are not evaluated in this ERA. Metals are of primary concern because of their potential for deposition and low, if any, loss rate from soil and water. These metals include arsenic, cadmium, chromium, cobalt, manganese, mercury, and nickel.

To determine air concentrations of the metals in soil and surface water, the concentration of PM_{10} was multiplied by the ratio of PM_{10} annual emission rate and annual emission rate of the metal. This approach was based on the assumption that all metals are a fraction of the PM_{10} air concentration. The estimated ground-level air concentration of each metal then was used to calculate soil and water concentrations using the following equation from the EPA combustion guidance (EPA, 1998b):

$$Cs = 100 * [(Dydw + Dyww)/(Zs*BD)]*tD$$

Where,

Cs = average soil or water concentration over exposure duration (mg/kg or mg/L),

100 = units conversion factor (mg-m^2/kg-cm^2),

Dydw = deposition rate of dry matter (g/m^2-yr),

Dyww = deposition rate of wet matter (g/m^2-yr),

Zs = soil or water mixing zone depth (cm) = 1 cm for soil, ~~609.6~~152.4 cm for surface water in a generic reservoir, and 60.96 cm for surface water in a generic river,

BD = soil or water bulk density (g/cm^3) = 1.5 g/cm^3 for soil and 1 g/cm^3 for water,

tD = time over which deposition occurs (time period of combustion) (yr) = 30 yrs.

These calculations were based on the following conservative assumptions:

- Standard deposition rates for use in wildlife risk assessments have not been developed. However, 0.02 m/s is the value recommended for use by the California Air Pollution Control Officers Association (CAPCOA, 1993) under their risk assessment guidelines (human health) in the air toxics program. ~~A literature-derived deposition rate of 0.02 m/s (CAPCOA, 1993).~~ This rate includes both dry and wet deposition and is highly conservative. In some cases, it has overestimated deposition by an order of magnitude (Howroyd, 1984). Therefore, a deposition rate of 0.02 m/s is considered conservative and appropriate for a screening-level assessment.

- The value for total wet and dry deposition "~~(~~Dydw + Dyww~~)~~" in the above equation was calculated by multiplying the predicted air concentration of the COPEC at ground level by the deposition rate. The predicted air concentration of the COPEC at ground level is assumed to be in the same proportion as their respective percent mass in PM_{10} (See Table 1). Although McFall Reservoir and Lost River are outside the area predicted to receive the highest concentration of PM_{10} (see Figure 1), other areas utilized by bald eagles (e.g., Smith Reservoir) fall within this area. Therefore, the maximum predicted air concentration within the significant impact area was used to estimate soil and surface water concentrations. This is the most conservative estimate of potential exposure from the predicted deposition of aerial emissions.

- No volatilization of metals occurs that results in 100 percent deposition of emissions. This is especially conservative for mercury because 100 percent of elemental mercury remains in the vapor fraction, and 85 percent of mercuric chloride is generally volatile (EPA, 1999).

- After deposition, no loss to processes, such as erosion, occurs.

- A mixing depth of 1 cm for soil was used as recommended in the combustion guidance (EPA, 1998b). For water bodies, a mixing depth of ~~20~~ 5 feet (~~609.6~~152.4 cm) for a generic reservoir (surrogate for McFall Reservoir, Smith Reservoir, Harpold Reservoir, Alkali Lake, and other surface waters in the area) and 2 feet (60.96 cm) for a generic river (surrogate for Lost River) were selected on the basis of best professional judgment given the latitude and elevation of areas surrounding the Energy Facility.

Table 2 presents summary statistics for predicted concentrations of each COPEC.

2.2.1 Process Wastewater Application

Maximum soil concentrations for the process wastewater application area were calculated from the predicted constituents in the process wastewater at 75 percent recovery (see Table 3). Aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, tin, and zinc were not detected in the aquifer source water; however, these metals are common in groundwater and likely exist at concentrations below the method reporting limits (MRLs). Therefore, as a conservative assumption, the MRLs for these metals were assumed to represent their concentration in the aquifer source water. Concentrations of these metals were predicted in the process wastewater by multiplying the MRL by a factor (1.954) based on the ratio of raw aquifer water concentration to predicted reject water concentration for metals with detected values (see Table 3).

A factor of 1.954 was determined using a total plant water balance approach. The source water was broken into two components: water and total dissolved solids (TDS). Water leaves the plant by evaporation and wastewater discharge and dissolved solids leave the plant in the wastewater discharge and with the resin from the Polishing Mobil DI. Evaporative losses do not contain dissolved solids; therefore, it was assumed that 98 percent of TDS would be removed in the reject water and the remaining 2 percent by the mobil DI. This results in a reject water TDS of almost two times the TDS in the aquifer source water (i.e., a 1.954 concentration factor). Because the metals are part of the TDS, their concentrations are also predicted to be 1.954 times greater in the reject water than in the aquifer source water.

Maximum soil concentrations (MSC) of reject water constituents for the process wastewater application area were determined using the following equation:

$$\text{MSC} = \frac{(PWC * AWP * L)}{(AA * MD * BD)}$$

Where,

MSC = maximum soil concentration (mg/kg)

PWC = predicted wastewater concentration of constituent (mg/L),

AWP = annual wastewater production (24.3 million gallons or 1,985,500 L),

L = life-span of the energy plant (30 years),

AA = wastewater application area (31 acres or 125,452 m^2),

MD = soil mixing depth for agricultural lands (20 cm or 0.2 m; EPA, 1998b),

BD = bulk density for soil (literature-derived value of 1,500 kg/m^3; EPA, 1998b).

This calculation assumes that constituents accumulate during the 30-year life span of the Energy Facility with no loss from biodegradation, erosion, leaching, or other biotic or abiotic loss mechanisms (see Table 3 for estimated MSCs).

2.2.3 Background Soil Concentrations

Soil concentrations derived from air emissions or process wastewater application represent incremental exposure. Plants, soil invertebrates, and wildlife also are exposed to background concentrations of many of the COPECs. Therefore, background values alone were also compared to screening benchmarks to determine the contribution of background to the total risk estimate. For this ERA, background values for Klamath County as reported by the U.S. Geological Service (USGS) (Boerngen and Shacklette, 1981) were used for all metals, except cadmium. In the absence of these data, the background value for the eastern portion of Washington (which is similar in climate) from the Washington statewide background values report (San Juan, 1994) was used. For comparison, a background concentration of cadmium at a location in California close to the Oregon border was 1.1 mg/kg compared to the Washington value of 1 mg/kg. Additionally, all background values used (Klamath County and Washington state) were generally within the lower range of values measured across the United States (Shacklette and Boergen 1984). Therefore, these regional background values were assumed to be representative of natural levels in the area and were considered appropriate for screening-level assessments in which limited site-specific data are available. ~~, as were Washington statewide background values (San Juan, 1994) when USGS values were lacking. These~~ The selected background values are presented in the risk characterization.

2.3 Assessment Endpoints and Measures of Exposure and Effects

Assessment endpoints are the ecological resources (e.g., potential receptors) that are present at a site and are to be protected. Measures of exposure and effects are the measures evaluated to provide an indication of whether assessment endpoints are sufficiently exposed such that adverse effects may have occurred or are likely to occur.

The areas surrounding the Energy Facility contain a variety of habitats, including riverine systems that support shortnose suckers, Lost River suckers, and bald eagles, which are all federally listed threatened or endangered species. Maintenance of resident aquatic resources is important to the success of these species. Moreover, maintenance of resident terrestrial habitats also is important to bald eagles, which use upland areas during the winter months when lakes and rivers are frozen (Brown and Amadon, 1968). Although Applegate's milk-vetch has been identified as a federally threatened or endangered species endemic to the area, this plant has not been observed in the area of major air emission deposition or in the process wastewater application area. EPA (1992a) identifies four criteria to consider when selecting assessment endpoints. The following is a summary of these criteria and their relationship to the assessment endpoints for the Energy Facility:

- Societal value: Threatened and endangered species (e.g., shortnose sucker, Lost River sucker, and bald eagle) are valued by society as evidenced by special protective legislation.
- Environmental policy goals: Threatened and endangered species (e.g., shortnose sucker, Lost River sucker, and bald eagle) are protected at the individual level.
- Ecological relevance: Aquatic organisms (aquatic plants, invertebrates, and fish) are integral components of the riverine ecosystem present in the Energy Facility area and plants, soil invertebrates, and terrestrial birds and mammals are integral components of the terrestrial ecosystem present in the Energy Facility area.
- Susceptibility to the stressor: Research has shown that aquatic organisms, plants, soil invertebrates, birds, and mammals may be adversely affected by exposure to the COPECs.

Aquatic organisms, terrestrial plants, soil invertebrates, birds, and mammals are potentially sensitive to contaminants and are considered ecologically important. Complete definitions of an assessment endpoint have three components (Suter et al., 2000): the entity, the attribute, and a level of effect. Table 4 summarizes the appropriate assessment endpoints and measures of exposure and effects.

Aquatic organisms, including fish, and bald eagles were evaluated for the aquatic pathways associated with air emissions. Terrestrial pathways for both air emissions deposition and irrigated reuse of process wastewater were evaluated using terrestrial plants, soil invertebrates, and terrestrial birds and mammals as receptors. Specific bird and mammal receptors included the western meadowlark and the deer mouse for the terrestrial assessment and the bald eagle for the aquatic assessment. Western meadowlarks and deer mice have foraging behaviors that are closely associated with the soil and, therefore, are likely to be highly exposed to COPECs in soil. Table 5 outlines relevant life-history parameters for these species.

2.4 Conceptual Site Model

The conceptual site model (CSM) is a description of predicted relationships between ecological receptors and the COPEC to which they might be exposed.

An exposure pathway can be described as the physical course that a COPEC takes from the point of release to a receptor. An exposure pathway is complete (i.e., there is exposure) if there is a way for the receptor to take in chemicals through ingestion, inhalation, or dermal absorption. To be complete, an exposure pathway must have all the following components:

- Chemical source
- Mechanism for chemical release
- Environmental transport medium
- Exposure point
- Feasible route of intake

In the absence of any of these components, an exposure pathway is considered incomplete, and, by definition, there can be no risk associated with that particular exposure pathway. Exposure can occur when chemicals migrate from their source to an exposure point (i.e., a location where receptors can come into contact with the chemicals) or when a receptor moves into direct contact with chemicals or contaminated media.

Two separate exposure scenarios were evaluated, one based strictly on air emissions and one on land application of process wastewater. Conceptual models for both scenarios are presented below.

2.4.1 Air Emissions

~~For purposes of this ERA~~Under the first scenario, the air emissions from natural gas combustion at the Energy Facility are considered the primary source of the COPECs. These COPECs may deposit from air to the soil and surface water within the areas surrounding the Energy Facility. Significant transport of COPECs from the deposition area is not expected. Soil and surface water are the affected media and both aquatic and terrestrial routes of exposure to the COPECs are evaluated in this ERA. Receptors are potentially exposed by way of root or foliar uptake, ~~dermal contact, inhalation,~~ direct ingestion, and ingestion of prey items.

A wide variety of wildlife (i.e., birds and mammals) is supported by the Klamath Basin's mix of habitats, and both terrestrial and aquatic routes of exposure to COPECs exist. Contaminants in water may be directly bioaccumulated by aquatic organisms resident in water bodies located in the vicinity of the Energy Facility, and contaminants in soil may be directly bioaccumulated by terrestrial plants or soil invertebrates. Both aquatic and terrestrial wildlife may be exposed directly to contaminants in soil or surface water by direct ingestion. Wildlife also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores) and this is expected to be the primary exposure route for wildlife. Exposure via dermal and inhalation routes although possible are considered trivial compared to ingestion exposure routes.

~~, by dermal contact, or by the inhalation of wind-borne particles. Little information is available on foliar uptake and inhalation routes, and exposure via these routes is expected to~~

~~be minimal; therefore, these pathways will not be evaluated. Although the dermal contact route of exposure exists for many birds and mammals, dermal exposure is likely to be low because of the presence of protective dermal layers (e.g., feathers, fur, scales). Wildlife also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores) and this is expected to be the primary exposure route for wildlife.~~

2.4.2 Process Wastewater Application

~~For purposes of this ERA~~Under the second scenario, the process wastewater from the Energy Facility is considered the primary source of the COPECs. These COPECs are transferred to soil in the 31-acre pasture area. Operations of the Energy Facility will be regulated under Oregon state permitting through the DEQ, which places controls on runoff and groundwater impact. To prevent runoff and deep percolation during irrigation, process wastewater will only be applied during the dry irrigation months of April to September and will not exceed agronomic crop water demands. Prior to the start-up of the process wastewater re-use facility, a full soil and hydrogeologic investigation will be conducted to determine selection of the application area. Additionally, monitoring of soil, groundwater, and irrigation water (quality and quantity) is required under the water pollution control permit to meet antidegradation rules for surface and groundwater. ~~Process wastewater will only be applied 8 months of the year and will not be applied during the winter.~~ Therefore, surface water and groundwater are not considered complete exposure pathways in this assessment. Soil is the affected medium and only terrestrial routes of exposure to the COPECs are evaluated in this ERA. ~~No aquatic routes of exposure are expected.~~ Receptors are potentially exposed via root and/or foliar uptake, ~~dermal contact, inhalation,~~ direct ingestion, and ingestion of prey items.

Contaminants in soil may be directly bioaccumulated by terrestrial plants or soil invertebrates. Terrestrial birds and mammals may be exposed directly to contaminants in soil or surface water by direct ingestion. Wildlife also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores) and this is expected to be the primary exposure route for wildlife. Exposure via dermal and inhalation routes although possible are considered trivial compared to ingestion exposure routes.~~, by dermal contact, or by the inhalation of wind-borne particles. Little information is available on foliar uptake and inhalation routes and exposure via these routes is expected to be minimal; therefore, these pathways will not be evaluated. Although the dermal contact route of exposure exists for many birds and mammals, dermal exposure is likely to be low because of the presence of protective dermal layers (e.g., feathers, fur, scales). Wildlife also may receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores) and this is expected to be the primary exposure route for wildlife.~~

3. Exposure Assessment

3.1 Aquatic Organisms

Aquatic organisms (aquatic plants, invertebrates, fish) experience exposure based on concentrations in water (i.e., exposure is water-mediated). Water-mediated exposure occurs as a consequence of living in a contaminated medium. Uptake of COPECs can be through the skin (dermal), through the gills, or through the diet, including ingestion of contaminated water and food. Water-mediated exposure to aquatic organisms is measured as a function of the concentration of contaminants in water (milligrams COPEC per liter water [mg/L]). Water-mediated exposure is used because most information on the effects of contaminants on aquatic organisms (described in Section 4.1) has been obtained from experiments where the exposure to contaminants was reported as a function of the concentrations of contaminants in water. To be conservative, the maximum estimated water concentration for each surface water type (i.e., generic reservoir and generic river) was selected as the suitable exposure point concentration.

3.2 Terrestrial Plants

Terrestrial plants experience exposure based on concentrations in soil (i.e., exposure is soil-mediated). Soil-mediated exposure occurs as a consequence of living in a contaminated medium. For plants, uptake of COPECs can be through roots. Soil-mediated exposure to plants is measured as a function of the concentration of contaminants in soil (milligrams lead per kilogram soil [mg/kg]). Soil-mediated exposure is used because most information on the effects of contaminants on plants (described in Section 4.2) has been obtained from experiments where the exposure to contaminants was reported as a function of the concentrations of contaminants in soil. Because plants are not mobile and to be highly conservative, the maximum estimated concentration was selected as the suitable exposure point concentration.

3.3 Soil Invertebrates

Like plants, soil invertebrates also experience soil-mediated exposure. Uptake of COPECs can be through the skin (dermal), or through the diet, including ingestion of contaminated soil and food. As with plants, most information on the effects of contaminants on soil invertebrates (described in Section 4.3) has been obtained from experiments where the exposure to contaminants was reported as a function of the concentrations of contaminants in soil. Therefore, the focus of the exposure characterization for soil-mediated exposures is the derivation of soil exposure point concentrations. Because mobility of terrestrial invertebrates is low, the maximum concentration was selected as the suitable exposure point concentration.

3.4 Birds and Mammals

Birds and mammals experience exposure through multiple pathways including ingestion of abiotic media (soil, sediment, and surface water) and biotic media (food) as well as inhalation and dermal contact. To address this multiple pathway exposure, modeling is required. Generally, the end product or exposure estimate for birds and mammals is a dosage (amount of chemical per kilogram receptor body weight per day [mg/kg/d]) rather than a media concentration as is the case for the other receptor groups (aquatic organisms, terrestrial plants, and soil invertebrates). This is a function of both the multiple pathway approach as well as the typical methods used in toxicity testing for mammals. However, ODEQ has developed soil screening-level values for birds and mammals and water screening-level values for birds for some contaminants based on conservative assumptions (ODEQ, 2001). These values are intended to be protective of terrestrial birds and mammals and aquatic birds, respectively, and were used as available. To be conservative, the maximum concentration was selected as the suitable exposure point concentration for comparison to the ODEQ screening values.

If no screening value was available for a COPEC, or a screening value was exceeded, receptor-specific exposure was calculated and compared to literature-derived toxicity values. Moreover, receptor-specific exposure was calculated for bald eagles because it is a special-status species. Summaries of total (i.e., sum over all pathways) and partial (pathway-specific) exposure estimates, as needed, are presented and compared to toxicity values in Section 5. The model used for estimating receptor-specific exposure and associated assumptions is described below.

Model

The general form of the model (Suter et al., 2000) used to estimate exposure of birds and mammals to COPECs in soil, surface water, and food items is as follows:

$$E_t = E_o + E_d + E_i$$

Where:

E_t = the total chemical exposure experienced by wildlife

E_o, E_d, and E_i = oral, dermal, and inhalation exposure, respectively

Oral exposure occurs through the consumption of contaminated food, water, or soil. Dermal exposure occurs when contaminants are absorbed directly through the skin. Inhalation exposure occurs when volatile compounds or fine particulates are inhaled into the lungs.

Although methods are available for assessing dermal exposure to humans (EPA, 1992b), data necessary to estimate dermal exposure generally are not available for wildlife (EPA, 1993). Similarly, methods and data necessary to estimate wildlife inhalation exposure are poorly developed or generally not available (EPA, 1993). If methods were available to permit the estimation of dermal and inhalation rates for birds and mammals, interpretation of the significance of these estimates would be problematic. This is because dermal and inhalation toxicity data for birds and mammals are broadly lacking. Owing to the lack of suitable exposure estimation methods and appropriate toxicity data, further evaluation of potential risks associated with the dermal and inhalation routes was not conducted. Both pathways were retained as uncertainties.

~~Therefore, for the purposes of this ERA, both dermal and inhalation exposure are assumed to be negligible. As a consequence, most exposure must be attributed to the oral exposure pathway. There are no surface water sources on the 31-acre process wastewater application area and, given the arid environment, all water applied to soil is assumed to be rapidly absorbed; therefore, water ingestion is considered an incomplete or insignificant exposure pathway. In contrast, deposition from air emissions is likely to occur in surface waters; therefore, water ingestion is included in the exposure calculations for air emission deposition.~~ By replacing E_o with a generalized exposure model modified from Suter et al. (2000), the previous equation was rewritten as follows:

$$E_j = \left[Water_j \times WIR\right] + \left[Soil_j \times P_s \times FIR\right] + \left[\sum_{i=1}^{N} B_{ij} \times P_i \times FIR\right]$$

Where:

E_j = total exposure (mg/kg/d)

$Water_j$ = concentration of chemical (j) in water (mg/L)

WIR = species-specific water ingestion rate (L water/kg body weight/d)

$Soil_j$ = concentration of chemical (j) in soil (mg/kg)

P_s = soil ingestion rate as proportion of diet

FIR = species-specific food ingestion rate (kg food/kg body weight/d)

B_{ij} = concentration of chemical (j) in biota type (i) (mg/kg)

P_i = proportion of biota type (i) in diet

Assumptions

To establish parameters for the exposure model, various assumptions were necessary. These assumptions are outlined below.

Exposure Point Concentrations. As with the comparisons to ODEQ screening values, a highly conservative approach was taken and the maximum estimated concentration was incorporated into the exposure model as the exposure point concentrations for soil and surface water. For evaluation of the air emissions scenario, maximum surface water concentrations estimated for the generic river were used as exposure point concentrations for meadowlarks. Because ~~there is primary concern for~~ bald eagles are expected to utilize~~ing~~ a variety of habitats in the area, ~~the McFall Reservoir,~~ exposure was calculated using both the generic reservoir and generic river surface water values (maximum concentrations) ~~were used~~ as exposure point concentrations ~~for bald eagles~~. Estimated soil concentrations under this scenario represent the maximum concentration predicted within the significant impact area (Note: this is the maximum concentration predicted for the Energy Facility vicinity.) As previously described, surface water is not present at the process wastewater application area; therefore, water ingestion was not included in the exposure calculation for meadowlarks and deer mice under this scenario. The maximum estimated soil concentrations within the process wastewater application area represent the exposure point concentrations for soil.

Life History Parameters. The specific life-history parameters required to estimate exposure of birds and mammals to COPECs include body weight, ingestion rate of food, ingestion rate of water (for air emissions analysis only), dietary components and percentage of the overall diet represented by each major food type, and approximate amount of soil that may be incidentally ingested based on feeding habits. These parameters, as well as home range information, were obtained from the literature and are presented in Table 5.

It should be noted that bald eagles in the area have a varied diet primarily consisting of carrion, small mammals, and waterfowl during the winter. During the nesting season, fish become and important component. For the purposes of this screening-level assessment, bald eagles were assumed to have a 100 percent fish diet. This is considered to be a conservative assumption because fish are year-round residents to the area, will forage exclusively within the area, and will experience 100 percent of their exposure from within the area. In contrast, waterfowl are migratory, will only spend a portion of the year in the area, and will only consume a portion of their diet from the area. Additionally, many of the constituents (e.g., mercury) are predicted to accumulate more in fish tissue than in bird tissue using available bioaccumulation models (discussed below). (Note: whereas bioaccumulation models are available for fish, such models for birds are lacking. To estimate concentrations in birds, available models for small mammals would have to be used a surrogate.)

Bioaccumulation Values. Measurements of concentrations of COPECs in wildlife foods are a critical component for the estimation of oral exposure in birds and mammals. Although the preferred data are direct measurements of concentrations in samples collected from the site, such data were not available in the vicinity of the Energy Facility. Therefore, literature-reported bioaccumulation factors (BAFs), regressions, or Kow-based models for terrestrial food items (foliage and insects) and literature-reported bioconcentration factors (BCFs) for aquatic food items were used.

BAFs or regressions were available for foliage (Bechtel-Jacobs, 1998; CH2M HILL, 2002), and insects (CH2M HILL, 2002) for the inorganics, models (K_{ow}-based) from EPA (2000) were used to estimate bioaccumulation factors (BAFs) for phenol in foliage and earthworms. The earthworm model was used as a surrogate for insects. To be conservative, the fraction of organic carbon required for the earthworm bioaccumulation model was assumed to be 1 percent. No foliage BAFs were available for cyanide, silver, thallium, or tin and no insect BAFs were available for cyanide, or tin; therefore, a BAF of one was assumed for these COPECs. BCFs were available for fish (Sample et al., 1997) for all COPECs, except cobalt and manganese. A BCF of one was assumed for these two COPECs. Table 6 summarizes the BAFs and BCFs used in the ERA.

4. Characterization of Ecological Effects

4.1 Aquatic Organisms

Screening-level toxicity values for aquatic organisms are provided by ODEQ guidance (ODEQ, 2001) and are shown in Table 7. For most cases, these values are the same as the National Ambient Water Quality Criteria (EPA, 2002) or chronic values developed at the Oak Ridge National Laboratory (ORNL) (Suter and Tsao, 1996). These values are intended to protect 95 percent of aquatic species, 95 percent of the time. Screening values are only shown for the COPECs associated with air emissions. An aquatic pathway is not complete for the process wastewater application (see Section 2.3).

4.2 Terrestrial Plants

Screening-level toxicity values for terrestrial plants are provided by ODEQ guidance (ODEQ, 2001) and are shown in Table 7. Most of these screening values are from the ORNL plant benchmarks report (Efroymson et al., 1997a). The protection of terrestrial plant communities from a 20 percent reduction in growth, reproduction, or survival is an assessment endpoint in this ERA. Therefore, benchmarks used to determine risk to this receptor group must be based on adverse effects related to these endpoints. The ORNL plant benchmarks were developed from studies that demonstrated at least a 20 percent reduction in the growth or yield of test plant species, which is consistent with the goals of the ERA. Additionally, growth and yield are important to plant populations and to the ability of the vegetation to support higher trophic levels; therefore, these are ecologically significant responses (Efroymson et al., 1997a).

4.3 Soil Invertebrates

Single-chemical screening-level toxicity values for soil invertebrates are provided by ODEQ guidance (ODEQ, 2001) and are shown in Table 7. Most of these screening values are from the ORNL soil invertebrate benchmarks report (Efroymson et al., 1997b) and are represented primarily by earthworms. The protection of terrestrial invertebrate communities from a 20 percent reduction in growth, reproduction, or survival is an assessment endpoint this assessment. Therefore, benchmarks used to determine risk to this receptor group must be based on adverse effects related to these endpoints. The ORNL soil invertebrate benchmarks were developed from studies that demonstrated at least a 20 percent reduction in the growth or survival of test invertebrate species, which is consistent with the goals of the ERA.

4.4 Birds and Mammals

Screening-level values for birds and mammals provided by ODEQ (ODEQ, 2001) were used as available in the ERA and are presented in Table 7. For birds, cobalt, iron, silver, thallium, and tin were lacking ODEQ screening values, but studies from which benchmarks could be developed for these metals were available. Similarly, iron, silver, tin, cyanide, and phenol benchmarks were developed for mammals from other sources. No data for birds were available for development of benchmarks for cyanide or phenol. Unlike the ODEQ screening values, which are presented as mg constituent per kg soil, these benchmarks are presented as a dose (mg constituent/kg body weight/day) to the receptor and were selected as described below.

Single-chemical toxicity data for birds and mammals consist of no observable adverse effect levels (NOAEL) or lowest observable adverse effect levels (LOAEL) derived from toxicity studies reported in the literature. The benchmarks for birds and mammals were obtained from several sources, including wildlife toxicity reviews, literature searches, wildlife benchmarks developed at ORNL (Sample et al., 1996), the EPA Region IX Biological Technical Assistance Group (BTAG) toxicity reference values (TRV) developed for the U.S. Navy (EFA West, 1998), and a Review of the Navy-EPA Region IX BTAG TRVs for Wildlife (CH2M HILL, 2000). Appropriate studies were selected based on the following criteria:

- Studies were of chronic exposures or exposures during a critical life-stage (i.e., reproduction).
- Exposure was oral through food, to ensure data were representative of oral exposures expected for wildlife in the field.
- Emphasis was placed on studies of reproductive impacts, to ensure relevancy to population-level effects.

- Studies presented adequate information to evaluate and determine the magnitude of exposure and effects (or no effects concentrations).

Multiple toxicity studies were available for birds and mammals for several analytes. Toxicity studies were selected to serve as the primary toxicity value if exposure was chronic or during reproduction, the dosing regime was sufficient to identify both a NOAEL and a LOAEL, and the study considered ecologically relevant effects (i.e., reproduction, mortality, growth). If multiple studies for a given COPEC met these criteria, the study generating the lowest reliable toxicity value was selected to be the primary toxicity value. Primary toxicity values were used for all initial evaluations of the exposure estimates and are highlighted in Table 8. Information concerning assumptions made as part of the extraction of data from each study is presented in the one attachment to this memorandum.

NOAELs and LOAELs for avian and mammalian receptors were estimated from literature data using allometric scaling methods presented in Sample et al. (1996) and Sample and Arenal (1999). Using the following equation, NOAEL or LOAEL for wildlife ($NOAEL_w$ or $LOAEL_w$) were determined for each species:

$$NOAEL_w = NOAEL_t \left(\frac{BW_t}{BW_w} \right)^{1-b} \text{ or } LOAEL_w = LOAEL_t \left(\frac{BW_t}{BW_w} \right)^{1-b}$$

where:

$NOAEL_t$	=	the NOAEL for a test species (obtained from the literature),
$LOAEL_t$	=	the NOAEL for a test species (obtained from the literature),
BW_t and BW_w	=	the body weights (in kg) for the test and wildlife species, respectively, and
b	=	the class-specific allometric scaling factor.

Scaling factors of 0.94 and 1.2 were applied for mammals and birds, respectively (Sample and Arenal, 1999). Table 9 presents these receptor-specific NOAELs and LOAELs.

5. Risk Characterization

In the risk characterization, exposure and effects data are combined to draw conclusions concerning the presence, nature, and magnitude of effects that may exist at the site. For all receptors (i.e., aquatic organisms, terrestrial plants, soil invertebrates, and birds and mammals), only literature-derived benchmarks were available. These were compared to maximum soil or water concentrations or dose based on maximum soil or water concentration to determine hazard quotients (HQs = exposure measure/effects measure) for each COPEC. Screening-level benchmarks are conservative; therefore, COPECs that are below these thresholds pass the screen and are not considered in future evaluations. However, HQs greater than one indicate a failure to pass the screen. Failure to pass the screen, however, cannot be concluded to represent the presence of risk. Rather, these results indicate that available data are insufficient to support a conclusion that ecological risks are absent. Constituents that failed the screen were reevaluated using more realistic assumptions.

Results of the screening evaluations for the deposition from air emissions scenario and the process wastewater application scenario are discussed below. Uncertainties that may influence these screening-level results are summarized in Section 5.3.

5.1 Air Emissions

Screening results for incremental, background, and total soil concentrations and incremental surface water concentrations (generic reservoir and generic river) against ODEQ screening values are presented in Tables 10 and 11, respectively. Table 12 presents bird and mammal screening evaluations based on receptor-specific parameters for COPECs that failed the ODEQ screen (chromium for birds), for COPECs lacking ODEQ screening values (cobalt for birds), and for bald eagles.

For terrestrial receptors (i.e., plants, soil invertebrates, and birds and mammals), chromium, manganese, and nickel failed to pass the screening evaluation when total (incremental + background) concentrations were evaluated (Table 10). Chromium exceeded the ODEQ screening values for plants, soil invertebrates, and birds; manganese exceeded the screening value for plants and soil invertebrates, and nickel exceeded the screening value for plants. However, in all cases, these exceedances were driven by background concentrations and no HQs greater than one were observed based on incremental concentrations. Background concentrations of certain metals (e.g., chromium) often exceed screening benchmarks. This does not necessarily indicate that background values present risk. Rather, this indicates the conservativeness of the screening benchmarks as well as limitations in the toxicity data used to develop the benchmarks. To be protective, screening benchmarks are frequently based on the lowest or 10th percentile concentrations associated with effects. Moreover, toxicity tests upon which screening benchmarks are based are often conducted using soluble salts added to test soils. These salts are generally more bioavailable than those forms present in the environment. Additionally, factors such as pH and organic content can reduce or increase the bioavailability of certain metals in the field relative to that in the laboratory tests and local organisms are often adapted to the background conditions in their environment. Therefore, it is generally assumed that background concentrations do not present risk to plants, soil invertebrates, and birds and mammals that frequent an area.

Because total chromium concentrations exceeded the ODEQ benchmark (HQ = 11.25) for birds and because no ODEQ avian screening value was available for cobalt, these COPECs were further evaluated using receptor-specific parameters to calculate exposure ~~to~~ for western meadowlarks (see Table ~~11~~12). In this evaluation, estimated oral exposure to chromium and cobalt was less than literature-derived benchmarks for these COPECs (see Table ~~11~~12). ~~Therefore~~The results of the terrestrial evaluation based on deposition of air emissions indicate that~~,~~ potential risks from chromium, manganese and nickel to plants, soil invertebrates, and birds are considered to be negligible.

Estimated maximum concentrations of all COPECs under both the generic reservoir and generic river scenarios were below ODEQ benchmarks for aquatic biota and aquatic birds (see Table 11). Therefore, no risk is expected from any of these COPECs. Because no ODEQ aquatic bird screening value was available for cobalt, this COPEC was further evaluated using receptor-specific parameters to calculate exposure (see Table ~~11~~12). Additionally, exposure calculations using receptor-specific parameters were performed for bald eagles because it is a special-status species that is of special concern within the deposition area of air emissions from the Energy Facility (see Table ~~11~~12).

None of the COPECs evaluated further exceeded oral exposure benchmarks for birds (i.e., all HQs were less than one) for the bald eagle under the generic reservoir (5-foot mixing depth) scenario (see Table ~~11~~12). Mercury exposure using surface water concentrations for the generic river (2-foot mixing depth), exceeded the NOAEL, but not the LOAEL. Because bald eagles are a protected species, exceedance of the NOAEL is of concern; therefore, mercury was evaluated qualitatively to determine its potential for risk to bald eagles. The magnitude of exceedance of the NOAEL is low (HQ = 1.5) suggesting that risk is also likely to be low. Moreover, mercury in the air emissions was assumed to be 100 percent in the particulate phase for estimation of soil and water concentrations. In fact, 100 percent of elemental mercury and 85 percent of mercuric chloride remains in the vapor phase and would be expected to volatilize. Therefore, estimated concentrations of mercury in soil and surface water are greatly over estimated resulting in gross overestimation of risk. Thus, deposition of metals from air emissions is considered to present no risk to aquatic organisms or bald eagles using reservoirs in the vicinity of the Energy Facility. Moreover, no risk to aquatic organisms, including the shortnose sucker and Lost River sucker, or birds using the riverine habitats in the vicinity of the Energy Facility is expected.

5.2 Process Wastewater Application

Screening results for incremental, background, and total soil concentrations against ODEQ screening values are presented in Table 13. Bird and mammal screening evaluations for COPECs lacking ODEQ values are presented in Table 14.

As indicated in Table 13, several process wastewater constituents (aluminum, barium, boron, chromium III, copper, fluoride, iron, manganese, molybdenum, and nickel) failed to pass the screening evaluation (i.e., HQs greater than one for any receptor) when total (incremental + background) concentrations were evaluated. However, the exceedances of all but boron, iron, and molybdenum were driven by background concentrations. It is notable that the ODEQ plant screening value for iron is not a soil concentration, but in fact, represents the screening value for iron in solution. Because it is not applicable to soil, this benchmark was considered inappropriate for use in the screening evaluation. Although risk to plants from iron exposure is uncertain, no incremental risk was found for soil invertebrates, birds, and mammals.

Additionally, incremental exposure to iron is ~~only 0.02~~less than 0.001 percent of the background exposure and is likely insignificant compared to background. Of the constituents evaluated separately for birds and mammals (dose calculations), only iron exceeded the NOAELs with HQs of 17 and ~~3,139~~3,140 for meadowlarks and deer mice, respectively (see Table 14). As with the evaluation in Table 13, these exceedances were driven by background iron concentrations with no exceedances of the toxicity reference values based on wastewater discharge alone. HQs for incremental exposure to iron were 0.004~~3~~ and 0.~~504~~748 for meadowlarks and deer mice, respectively. Therefore, the incremental exposure to plants, soil invertebrates, birds, and mammals from the process wastewater application is expected to be minor for all constituents, except for boron and molybdenum exposures to plants and boron exposures to invertebrates. Constituents for which toxicity benchmarks are lacking were not evaluated and remain an uncertainty. Additionally, salts and total dissolved solids (TDS) were evaluated elsewhere in the BA.

Estimated maximum incremental boron concentrations in soil were ~~93~~ 79 times the plant screening value of 0.5 mg/kg. However, the screening value represents the toxicity level for highly sensitive plant species. For boron-tolerant species (e.g., alfalfa), toxicity thresholds are approximately 2 to 4 mg/kg (Brown et al., 1983). This reduces the HQ from ~~53.4~~79.2 to approximately ~~23.3~~19.8 to ~~11.7~~9.9 for the boron-tolerant species selected for planting in the application area. Moreover, less than 5 percent of the total boron in soil is available for uptake to plants (Eisler, 2000), reducing the estimated incremental exposure from ~~26.7~~39.6 mg/kg to ~~1.33~~1.98 mg/kg and the total exposure from ~~46.7~~59.6 to ~~2.33~~2.98 mg/kg. Though these concentrations still exceed the screening level derived for sensitive plants species, they are below concentrations associated with toxic effects to boron-tolerant plants when considering boron bioavailability. Boron concentrations adjusted for bioavailability are also below the screening level for invertebrates.

Molybdenum is an essential micronutrient that is not highly toxic to plants, but bioaccumulates in plant tissue and is generally of concern to higher trophic organisms (Eisler, 2000). Ruminants (e.g., cattle and sheep) in particular can be sensitive to molybdenum exposure in forage because excess molybdenum may result in a copper deficiency (Eisler, 2000). However, the maximum estimated total molybdenum concentration in soil did not exceed the screening benchmarks for birds and mammals and is therefore unlikely to pose risk to these receptors.

Although the molybdenum benchmark for plants was exceeded, risk to terrestrial plants from molybdenum exposure is considered low because of the low exceedance of the screening value (HQ = ~~2.7~~3.3 for total molybdenum). Additionally, the highly conservative assumptions applied to the risk estimation likely result in an overestimation of molybdenum exposure. First, molybdenum was not measured in the raw aquifer water and was therefore estimated using the minimum reporting limit. Moreover, the maximum soil concentration of molybdenum was estimated assuming a wastewater output of 24.3 million gallons based on a 72 percent capacity factor for the Energy Facility. The actual capacity of the Facility will likely be closer to 40 percent, resulting in the creation of 13.5 million gallons of wastewater. At 40 percent capacity, the estimated soil concentration of molybdenum from wastewater application would be reduced from ~~2.41~~3.58 to ~~1.34~~1.99 mg/kg, a value below the screening benchmark for plants. Finally, the calculation used to estimate soil concentrations from wastewater application assume that there is no loss due to abiotic or biotic factors. As a consequence, the calculated molybdenum concentration likely represents an overestimate of exposure to organisms.

5.3 Uncertainty Analysis

Uncertainties are inherent in all risk assessments. The nature and magnitude of uncertainties depend on the amount and quality of data available, the degree of knowledge concerning site conditions, and the assumptions made to perform the assessment. The following is a qualitative evaluation of the major uncertainties associated with this assessment, in no particular order of importance:

- Concentrations of COPECs in soil and surface water were wholly estimated on the basis of predicted concentrations of COPECs in air emissions and process wastewater from the Energy Facility. Although this uncertainty may result in underestimation of exposure (and risk), the conservative assumptions applied to air emission and process wastewater predictions, as well as the conservative assumptions used to convert these concentrations to soil and water concentrations, likely result in an overestimation of risk.

- Literature-derived values for bulk density of soil, soil and water mixing depths, and deposition rate of air emissions were used to calculate soil and water concentrations. The suitability of these literature values is unknown, although these are conservative values. Therefore, risk may be underestimated, but is likely overestimated.

- Based on best professional judgment, mixing depths of 20 feet for reservoirs and 2 feet for rivers were selected for estimating surface water concentrations from air emissions deposition. The suitability of these values is unknown. Consequently, risk may be over- or underestimated.

- Constituents in wastewater were estimated assuming a 72 percent capacity factor for the Energy Facility. It is more likely that the Facility will be operated at approximately 40 percent capacity. Therefore, wastewater concentrations and resulting risk are likely overestimated.

- Molybdenum, copper, and sulfur have complex interactions in soil that can result in increased or decreased toxicity to foraging animals. For example, excess molybdenum can cause a copper deficiency, though adequate molybdenum can decrease toxicity associated with excess copper. Because of the uncertainties in the risk estimation (e.g., copper and molybdenum were not detected in the raw aquifer water) and the complex nature of these constituents, it is uncertain whether risk was over- or underestimated for copper and molybdenum, although effort was made to overestimate risk through the conservative set of assumptions.

- Data concerning soil ingestion rates for bird and mammal receptors were not available. As a consequence, the soil ingestion rates were estimated on the basis of assumed similarities to other species for which data were available. The suitability of these assumptions is unknown. Although this uncertainty may result in underestimation of exposure (and risk), it is more likely that exposure and risk are overestimated.

- No life history data specific to the COB Energy Facility area were available; therefore, exposure parameters were either modeled on the basis of allometric relationships (e.g., food ingestion rates) or were based on data from the same species in other portions of its range. Because diet composition as well as food, water, and soil ingestion rates can differ among individuals and locations, published parameter values may not accurately reflect individuals present at the site. As a consequence, risk may be either overestimated or underestimated.

- No site-specific data on COPEC concentrations in fish, terrestrial plants, and soil invertebrates were available for wildlife exposure estimate calculations. Therefore, concentrations in these prey items were estimated from literature-reported bioaccumulation models (BCFs, 90th Percentile BAFs, regressions, or Kow-based). The suitability of these bioaccumulation models is unknown. As a consequence, concentrations of COPECs in prey items of wildlife may be either greater than or less than data used in this assessment.

- Literature-derived toxicity data based on laboratory studies were used to evaluate risk to all receptor groups. It was assumed that effects observed in laboratory species were indicative of effects that would occur in wild species. The suitability of this assumption is unknown. Consequently, risk may be either overestimated or underestimated.
- Literature-derived toxicity data are not available for western meadowlarks, bald eagles, or deer mice. Therefore, laboratory studies on the effects of COPECs on test species (e.g., quail, chicken, mallard, rat, mouse, rabbit) were used to evaluate risks to these receptors. It was assumed that effects observed in these test species were indicative of effects that would occur in the receptor. However, sensitivity to COPECs can vary between species, and this variation may be even more varied between taxonomic groups (i.e., galliforms versus raptors). Consequently, risk may be either overestimated or underestimated.
- Toxicity data are not available for all COPECs considered in this ERA. As a consequence, COPECs for which toxicity data are unavailable were not evaluated. Exclusion of COPECs from evaluation underestimates aggregate risk.
- Bioavailability in the toxicity studies used for screening is generally high because many toxicity tests are performed using soluble salts of inorganic chemicals. Therefore, risk based solely on literature-derived toxicity values may be overestimated.
- Because toxicity data are not available for individual bird and mammal receptors, it was necessary to extrapolate toxicity values from test species to site receptor species. Although improved class-specific scaling factors were employed (Sample and Arenal, 1999), these factors are not chemical-specific and are based on acute toxicity data. As a consequence, risk may be either overestimated or underestimated.
- In this assessment, risks from COPECs each were considered independently (i.e., no ambient media toxicity data were available). Because chemicals may interact in an additive, antagonistic, or synergistic manner, evaluation of single-chemical risk may either underestimate or overestimate risks associated with chemical mixtures.
- Due to lack of exposure estimation methods and toxicological effects data, dermal and inhalation exposure were not evaluated for birds and mammals in this assessment. As a consequence, cumulative exposure estimates may be underestimated. However, because exposure was based on conservative assumptions and because the oral pathway (i.e., ingestion of contaminated media and prey) is the primary exposure route, underestimation of total exposure is considered trivial.

6. Conclusions

6.1 Air Emissions

For terrestrial receptors (i.e., plants, soil invertebrates, birds, and mammals), chromium, manganese, and nickel failed to pass the screening evaluation when total (incremental + background) concentrations were evaluated. However, in all cases, these exceedances were driven by background concentrations. Receptor-specific evaluation of chromium and cobalt exposure to birds resulted in no exceedances of literature-based toxicity thresholds. Therefore, exposure to arsenic, cadmium, cobalt, and mercury associated with air emissions from the Energy Facility poses no risk to plants, soil invertebrates, birds, and mammals, whereas potential risks to plants, soil invertebrates, and birds from exposure to chromium, manganese, and nickel are considered to be negligible.

None of the COPECs exceeded benchmarks for aquatic receptors; therefore, deposition of air emissions from the Energy Facility to surface water poses no risk to aquatic organisms, such as the shortnose sucker~~,~~ and Lost River sucker. Though mercury under the generic river scenario (2-foot mixing depth) exceeded the NOAEL for bald eagles, this exceedance was low. Additionally, mercury is primarily found (85 percent or greater) in the vapor phase and therefore estimates based on 100 percent in the particulate phase greatly overestimate mercury deposition. Therefore, no risk to ~~, and~~ bald eagles from air emissions is predicted.

6.2 Process Wastewater Application

Process wastewater constituents evaluated, except aluminum, barium, boron, chromium III, copper, fluoride, iron, manganese, molybdenum, and nickel, passed the screening evaluation and are considered to present no risk to ecological receptors. After further evaluation, background concentrations were found to be the primary driver for screening failures of aluminum, barium, chromium III, copper, fluoride, iron, manganese, and nickel, with negligible incremental contributions of these constituents to the risk estimation. Considering the bioavailability of boron to plants (less than 5 percent of total boron) substantially reduced the risk estimation for boron. Although both incremental and total (incremental + background) boron concentrations continued to exceed screening levels for sensitive plant species, incremental and total exposures were below toxicity thresholds for invertebrates and for boron-tolerant plant species when adjusted for boron bioavailability. Estimated maximum concentrations of molybdenum exceeded the soil benchmark for plants; however, risk to terrestrial plants from molybdenum exposure is considered low owing to the low exceedance of the screening value and the highly conservative assumptions applied to the risk estimation. Thus, none of the constituents evaluated are considered to present significant risk to ecological receptors.

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Figure

Tables

Attachment